Journal of Nursing & Interprofessional Leadership in Quality & Safety

Volume 2 | Issue 1 Article 1

2018

Meta-analysis of the Effects of Exercise Interventions on Obese Adolescents

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Abstract
A meta-analysis of 10 randomized control studies published in 2003-2013 was conducted to provide a summary of the effects of exercise interventions on obese adolescents. Outcomes of the reviewed trials included body mass index, weight, glucose, and triglycerides. Data were combined using an inverse variance weighted random effects model. The effect size estimate for BMI was 1.354 kg/m^2 ($p < 0.001$, SE 0.321), indicating that the BMI of individuals in treatment groups improved, as compared to control groups. A statistically significant reduction in weight was greater in the intervention groups than the control groups by 3.815 kg ($p = 0.001$, SE 1.101). The findings of this meta-analysis show that exercise interventions may improve control of weight and BMI and in turn be a factor in decreasing obesity.

Keywords
Obese adolescent, exercise, exercise intervention, BMI, weight

Cover Page Footnote
This work supported in part by the NIH/NCATS Clinical and Translational Science Award to the University of Florida UL1 TR000064.

Introduction

Over the past decades, adolescent obesity in the United States has tripled, creating a public health crisis that spans socioeconomic class, race, and gender (Chen, Kim, Houtrow, & Newacheck, 2010). Results of The National Health and Nutrition Examination Survey revealed an alarming trend. The prevalence of obesity among adolescents in the years 1966-1970 was 4.6% and in the years 2007-2008, 18.1% (National Center for Health Statistics, 2010). Furthermore, 70% of those categorized as obese continued the trend into adulthood (Stice, Shaw, & Marti, 2006). Obesity could reduce life expectancy by 5 to 20 years, depending on gender and race (Fontaine, Redden, Wang, Westfall, & Allison, 2003). As a result, adolescent obesity comprises the dominant health crisis confronting America's youth (Jasik & Lustig, 2008). Obesity's fiscal costs are estimated to be approximately $100 billion annually (Stice et al., 2006). Thus, there is a need to determine effective strategies to treat and prevent obesity, not only to improve health outcomes but also to reduce healthcare costs associated with obesity.

Complications associated with childhood obesity have been identified as social isolation, decreased physical functioning, increased likelihood of depression, lower self-esteem, stigma and discrimination, and increased risk for medical complications (Curtin, Bandini, Perrin, Tybor, & Must, 2005; Holcomb, Pufpaff, & McIntosh, 2009). The detrimental effects of childhood obesity may pose even greater difficulties during adolescence, especially in relation to biological, psychological, and social functioning. Although adolescence may be a difficult transition for some individuals, it is a time of increased independence and discovery of self, which can foster ownership of health and lifestyle. Therefore, adolescence may be an ideal time to address physical activity and healthy lifestyle choices.

In general, research related to obesity in adolescence has focused on two main areas with mixed results: prevention and treatment. One review demonstrated positive effects of obesity prevention programs (Gonzalez-Suarez, Worley, Grimmer-Somers, & Dones, 2009), while another review noted that only a small number of adolescents seek help in managing obesity, and the current treatment of choice, behavioral family-based interventions, yields only a 10% reduction in body weight (Stice et al., 2008).

Researchers have implemented school based interventions to address the concerns of adolescent obesity (Gonzalez-Suarez et. al, 2009; Harris, Kuramoto, Schulzer, & Retallack, 2009) and recommended medical approaches such as bariatric surgery for the pediatric population (Treadwell, Sun, & Scholles, 2008). However, few reviews have exclusively addressed physical activity.

Methods

Data Sources

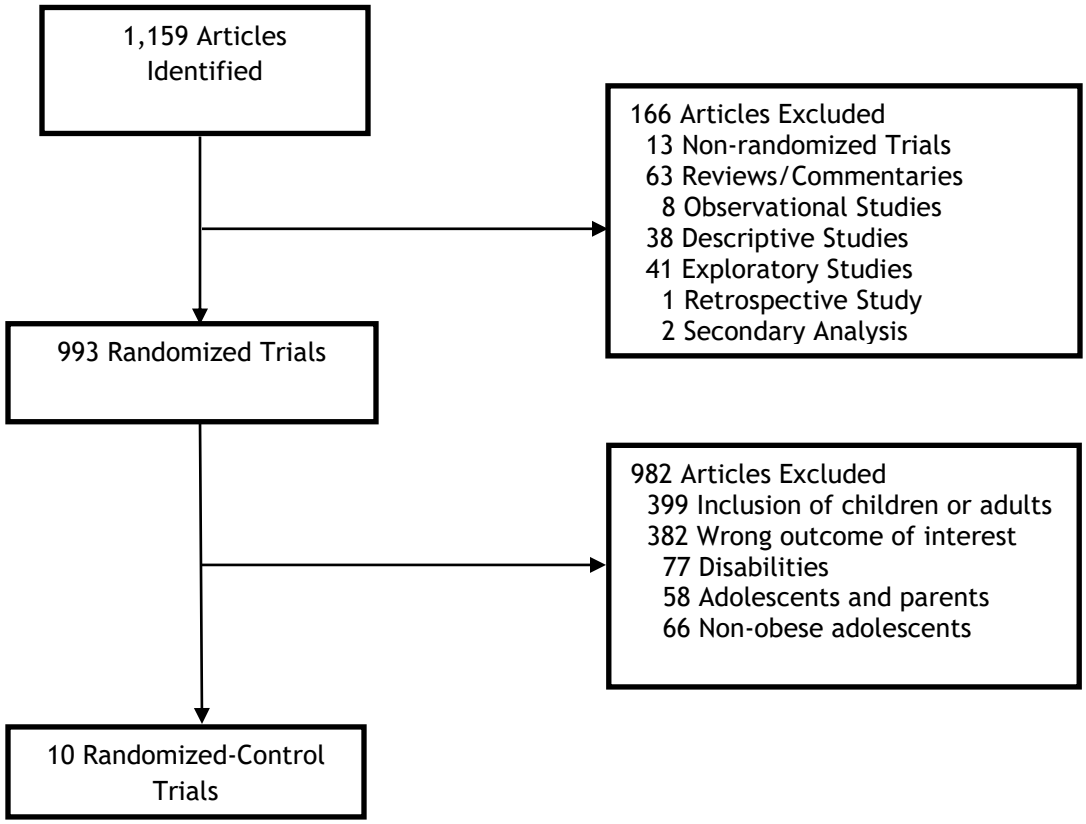
A comprehensive search was performed using PubMed, CINAHL, Google Scholar, and Cochrane Central Register of Controlled Trials. Key words were *obese adolescents*, *physical activity*, and *exercise*. The search was limited to articles published in the English language between the years 2003-2013. The term "obesity" refers to weight above the 95th percentile for age and sex (Centers for Disease Control and Prevention [CDC], 2014). The selection criteria were as follows:

- Sample comprised of obese adolescents (11.0 – 19.0 years)

- Intervention must be a physical activity designed to reduce weight and/or body mass index (BMI) without pharmacological assistance
- Design included treatment and control groups, with a minimum of 5 subjects each
- Both pre- and post-intervention weight and BMI were recorded

Of the 1159 potentially eligible studies identified, 1149 did not meet selection criteria. The process of deselection resulted in identification of 10 randomized control trials. The 10 studies were published in peer-reviewed publications and (excepting one), reported funding source. Literature search results are shown in Figure 1.

Figure 1. Schematic Diagram of Literature Search



The 10 trials yielded 744 adolescent subjects, where physical activity interventions included exercise (3 studies), exercise with strength training (1 study), exercise with nutrition (5 studies), and strength training with nutrition (1 study). The control group activities were usual care, nutrition only, no exercise, or adolescents on a waiting list for treatment. The duration of interventions varied in length from 8 weeks to two years.

Data Synthesis and Analysis

To ensure that independent samples were analyzed, samples were crosschecked to avoid overlapping numbers. To ascertain resulting patterns, the difference in post-test means and standard errors, where SE=SQRT (SE_1^2 + $SE_2^{2,}$) was calculated. In this case, SE_1 and SE_2 were the

standard errors for the treatment and control groups, respectively. All *p* values were two-tailed. Results were combined using random effects with inverse variance weights as changes from baseline were not available. Because multiple intra-intervention and post-intervention BMI and weight values were available in many of the studies, final post-intervention weight, BMI, and glucose or triglyceride values were used in the analysis. Comprehensive Meta-Analysis Version 3.0 was used for the calculations (as obtained from (http://www.meta-analysis.com/index.php).

Results

Studies differed in data reported. Six studies reported age and gender, whereas one study did not; three studies reported age, gender, and ethnicity; and one study did not report mean age. The mean age of participants was 14.67 years with a range of 11-19 years. Of the data available, 372 were female and 219 were male, whereas 98 were Asian, 89 were Hispanic/Latino, and 3were Native American (number of Caucasians was unknown). Table 1 describes characteristics of participants enrolled in the 10 randomized-control trials. Complete citations for the 10 studies of the meta-analysis are shown in the Reference Section.

Table 1: Characteristics of trials and participants included in meta-analysis

Trial (Year)	No. of Subjects	Mean Age (Year)	Male	Female	Race, N (%)	Exercise Intervention
DeBar et al. (2012)	208	14.10	N/A	208	N/A	EX + N
Kong, et al. (2013)	51	15.00	18	33	Hispanic, 35 (69%); Asian, 5 (10%); Native American, 3 (6%); Multiple, 8 (15%)	EX + N
Nowicka, et. al (2008)	88	13.60	44	44	Asian 93 (100%)	EX + N
Ounis, et. al (2008)	24	13.20	24	N/A	N/A	EX + N
Toulabi, et. al (2012)	152	15.87	N/A	N/A	N/A	EX + N
Sun, et. al (2011)	93	14.81	44	43	N/A	EX
Tsang, et. al (2009)	20	13.10	8	12	N/A	EX
Wong, et. al (2008)	24	13.75 (e) 14.25 (c)	24	N/A	N/A	EX
de Mello et al. (2011)	30	16.71	20	10	N/A	EX + S
Davis et al. (2009)	54	15.50	35	19	Latino, 54 (100%)	N + S
Total	744					

Note. N/A - data not available; EX -exercise therapy; N -nutrition; S - strength training

Effect Sizes for Exercise Interventions

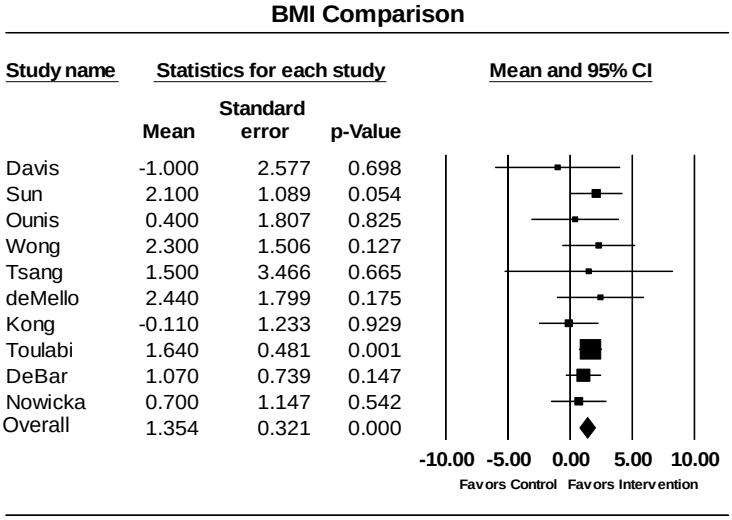
Analyses were conducted on the effect size for change in outcomes of interest in the treatment group versus the control group. Effect sizes for outcomes of exercise interventions are

displayed in Figures 2-5, which show meta-analysis effect size estimates for BMI, weight, triglycerides, and glucose using random effects models. The effect size estimates were calculated using computed effect sizes of raw data with the means and standard errors.

Exercise effect on BMI.

Random effects meta-analysis of BMI was used to estimate the effects of exercise interventions on BMI. The effect size estimate for BMI was 1.354 kg/m^2 (p < 0.001, SE 0.321), indicating the post-intervention BMI of individuals in the treatment groups improved compared to the control groups, as shown in Figure 2. Thus, treatment groups had a significant reduction in BMI post-intervention

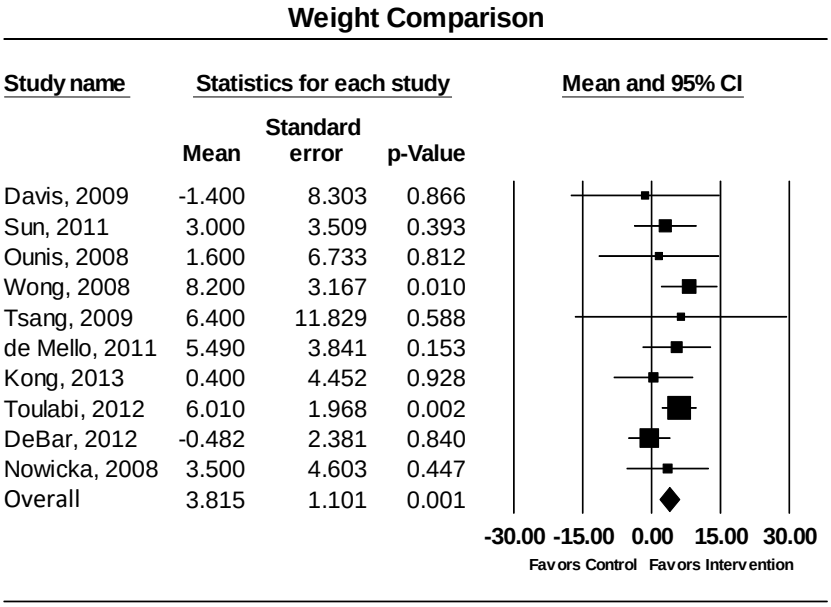
Figure 2. The Effect of Exercise on BMI: Control minus Intervention at Post-test.



Exercise effect on weight.

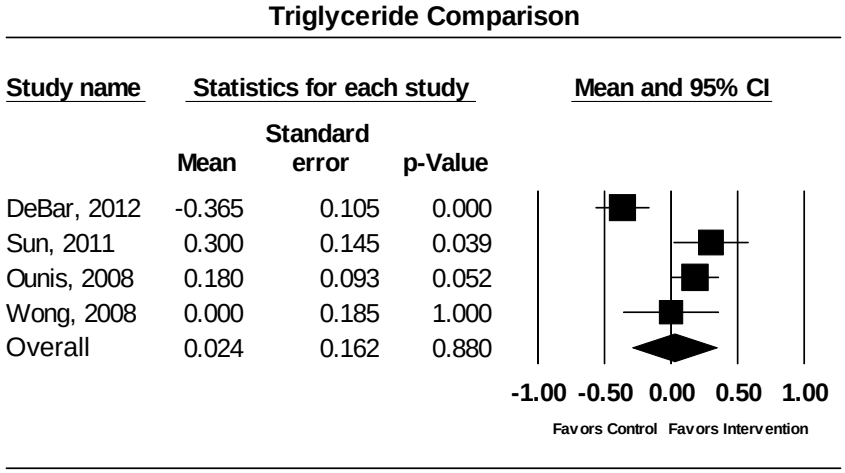
Random effects meta-analysis of exercise interventions on weight demonstrated a statistically significant greater reduction in weight for the intervention groups, as compared to the control groups by 3.815 kg (p = 0.001, SE 1.101), as shown in Figure 3.

Figure 3. The Effect of Exercise on Weight: Control Minus Intervention at Post-Test.



Effect on Triglycerides. Triglyceride levels were similar for the two groups at 0.007 (p = 0.905, SE 0.059, as shown in Figure 4. There was considerable heterogeneity amongst the studies of triglyceride levels.

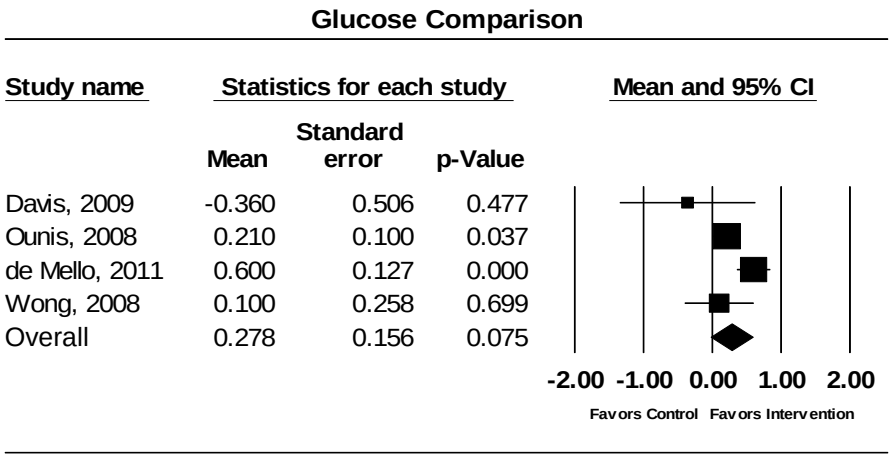
Figure 4. The Effect of Exercise on Triglycerides: Control minus Intervention at Post-test).



Effect on Glucose.

Glucose improved for the intervention groups, as compared to the control group, with a mean difference 0.278 (control less experimental). However, it was not statistically significant (p = 0.075, SE 0.156), as shown in Figure 5.

Figure 5. The Effect of Exercise on Glucose: Control minus Intervention at Post-test.



Discussion

The meta-analysis results support the premise that exercise interventions improve BMI, weight, glucose, and triglycerides in obese adolescents. The improvement in BMI (1.354) and weight (3.815) were similar to previously published meta-analyses (Stice et. al, 2006; Gonzalez-Suarez et. al, 2009). Exercise interventions may improve health outcomes that can affect potential co-morbidities in adulthood. At the very least, the slight improvement demonstrates a slower progression of co-morbidities in adulthood.

Complications associated with adolescent obesity are well known and affect numerous systems. Must and Anderson (2003) note such complications could be neurological (idiopathic increased intracranial hypertension), endocrine (insulin resistance, impaired glucose tolerance, Type 2 diabetes, menstrual abnormalities, polycystic ovary syndrome), pulmonary (sleep apnea, asthma), gastrointestinal (cholelithiasis and liver steatosis), and orthopedic (slipped capital epiphyses, tibial torsion). The authors further note that complications place an increased burden on physical and psychosocial health as well as serve to increase morbidity and mortality. Thus, a need exists for proven interventions that reduce weight and improve health outcomes.

While the degree of improvement in BMI and weight are clinically significant, the results may underestimate the true effects of exercise interventions. In 4 of the 10 studies, the authors reported an increase in weight and/or BMI for the control group due to these participants continuing nutrition as usual. The remaining study findings demonstrated a minimal reduction in BMI and/or weight, which suggests that even slight changes in BMI and/or weight may slow or reduce weight gain commonly seen in adolescent obesity. A possible explanation is that the intervention was not long enough to result in a steady weight gain. The majority of interventions reported were of 8 to 12 weeks duration, which may not have been long enough to capture the full effect of the intervention. Interventions likely need to have adequate time to reach a steady state. Future studies should consider interventions that are adhered to in longer timeframes.

Adolescent obesity contributes to early onset of arthrosclerosis and may result in increased lifetime risk of cardiovascular disease and Type 2 diabetes (Stice et al., 2006). The results for triglyceride and glucose levels validate the clinical significance of exercise interventions for obese

adolescents. Exercise could reduce the epidemiological and economic impact of adolescent obesity. Because increases in magnitude are projected as obese youth become obese adults, an increasing percentage of adults will require life-long treatment for obesity-associated comorbidities. However, altering life styles to benefit from long-term weight gain prevention may be difficult (Jeffery et al., 2000; Stice et al., 2006).

Limitations

Caution should be taken when interpreting the meta-analysis results. The studies reviewed indicated that the type of and length of exercise interventions varied considerably. Although patterns were shown, the inconsistency may have influenced the overall effects of the meta-analysis. Because this study is meta-analysis, the emerging patterns need to be updated as new randomized controlled study are conducted on large sample sizes of obese adolescents.

Conclusion

Because obesity in adolescence is a serious health concern, the purpose of this meta-analysis was to assess existing literature to summarize knowledge and suggest directions for future research. Findings from this meta-analysis provide evidence of the positive effect of exercise interventions. Exercise was found to improve weight and BMI, and to a lesser extent, glucose and triglycerides levels. While some interventions were short in duration, overall results indicate that exercise can change measures of adiposity, which may reduce comorbidities that can shorten lifespan and create medical complexities that decrease quality of life. Future studies should focus on prospective evaluation interventions over longer periods of time. Attention should also be paid to weight gain prevention through adolescence and into young adulthood.

Relevance to Clinical Practice

The results of this meta-analysis yield valuable insight for clinical practice. Obesity prevention should be targeted early in life. For children and adolescents, BMI should be annually calculated and documented in the subjects' medical records. A focused system review and physical examination will aid providers in assessing obesity-related comorbid conditions. If obesity is present, weight management intervention strategies should be made available that include nutritional, physical activity, and behavior modification information. To promote behavior change, providers should implement motivational interviewing techniques and fully investigate barriers to making health behavior changes. Health care providers will also need to document and educate parents on factors that may impact obesity, such as risks of ingesting high fat or sugar content foods. Obesity prevention and management requires a team approach, and providers need to be aware of clinical and community resources available to families. Providers need to build trust and establish an ongoing therapeutic relationship with the family. In addition, they need to assist the child and family in setting specific goals.

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